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(54) **METHOD AND SYSTEM FOR POWER CONTROL IN WIRELESS PORTABLE DEVICES USING WIRELESS CHANNEL CHARACTERISTICS**

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(52) **U.S. Cl.** **455/574**; 455/226.1; 455/226.2; 455/226.3; 455/513; 455/343.2

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See application file for complete search history.

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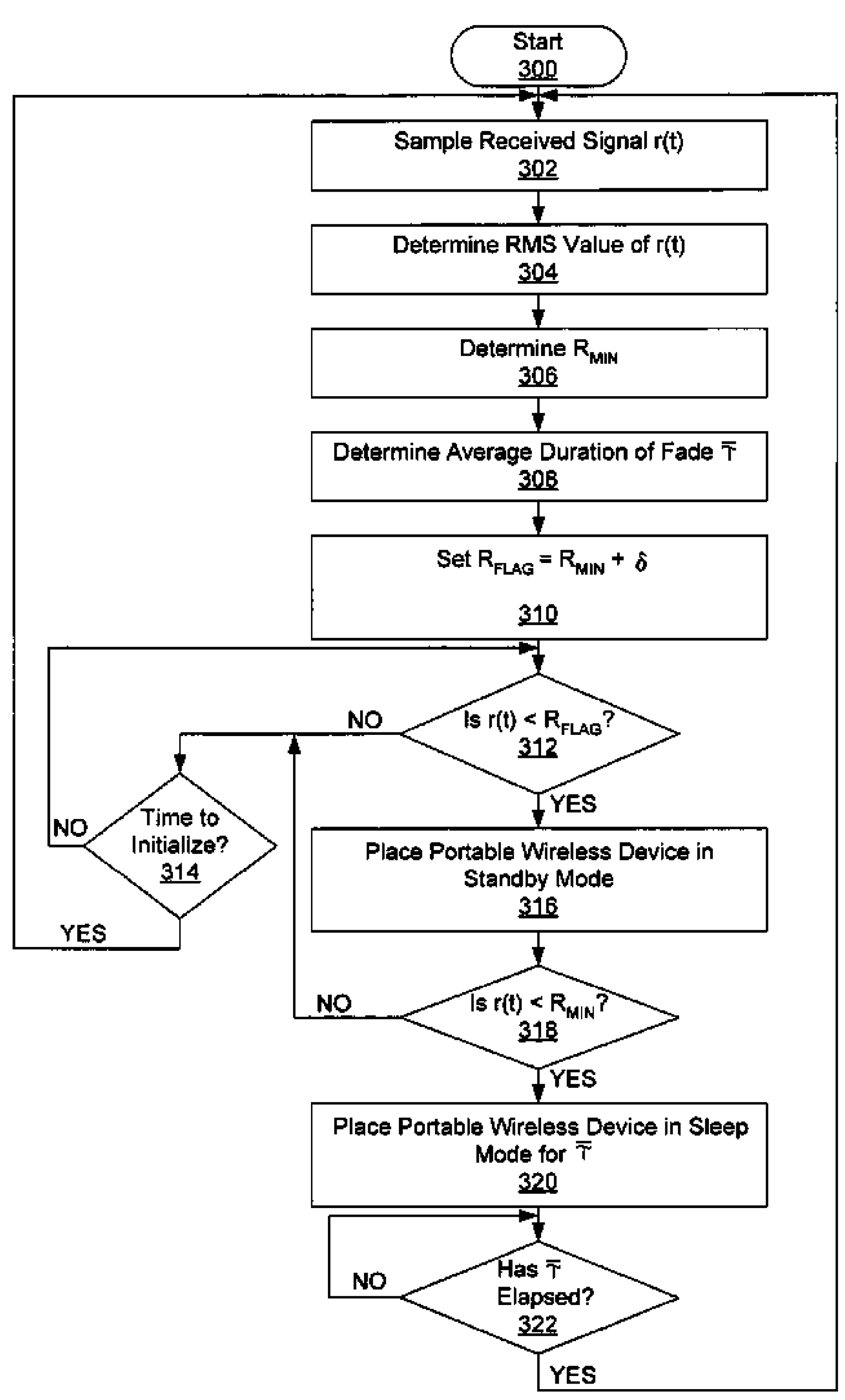
(57) **ABSTRACT**

A method controls the operation of devices which communicate over a wireless communications channel. The method includes determining a parameter of a received signal communicated over the wireless communications channel and determining a minimum threshold value of the received signal. An average duration of fade is determined using the parameter and the minimum threshold. The method detects whether the received signal is less than the minimum threshold value. At least one of the devices is placed in a sleep mode for approximately the average duration of fade in response to the received signal being detected as less than the minimum threshold value. The determined parameter of the received signal may be the root mean square value of the received signal.

25 Claims, 3 Drawing Sheets



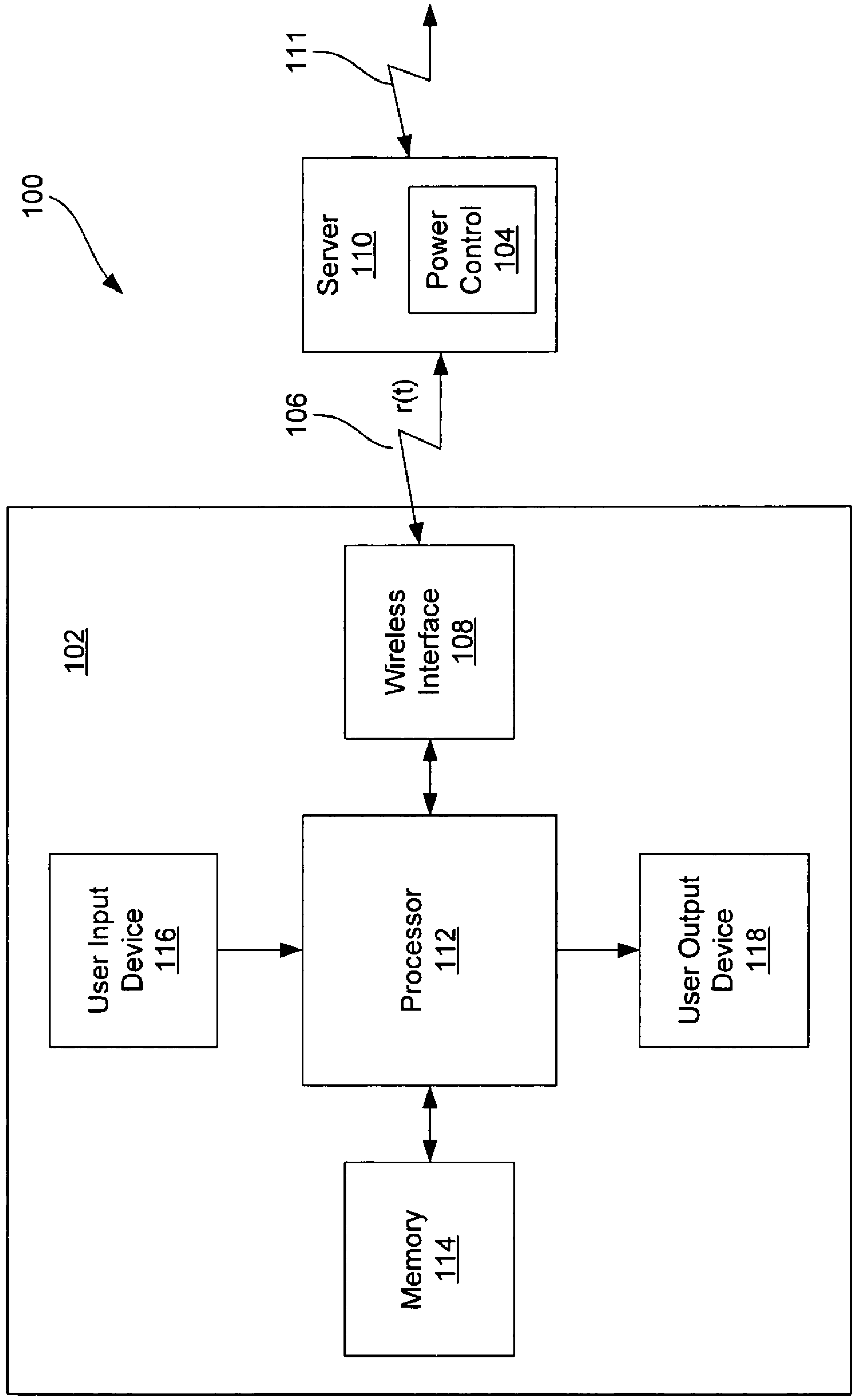

100
111
Server
110
Power
Control
104
106
r(t)
102
Wireless
Interface
108
User Input
Device
116
Processor
112
User Output
Device
118
Memory
114

FIG. 1

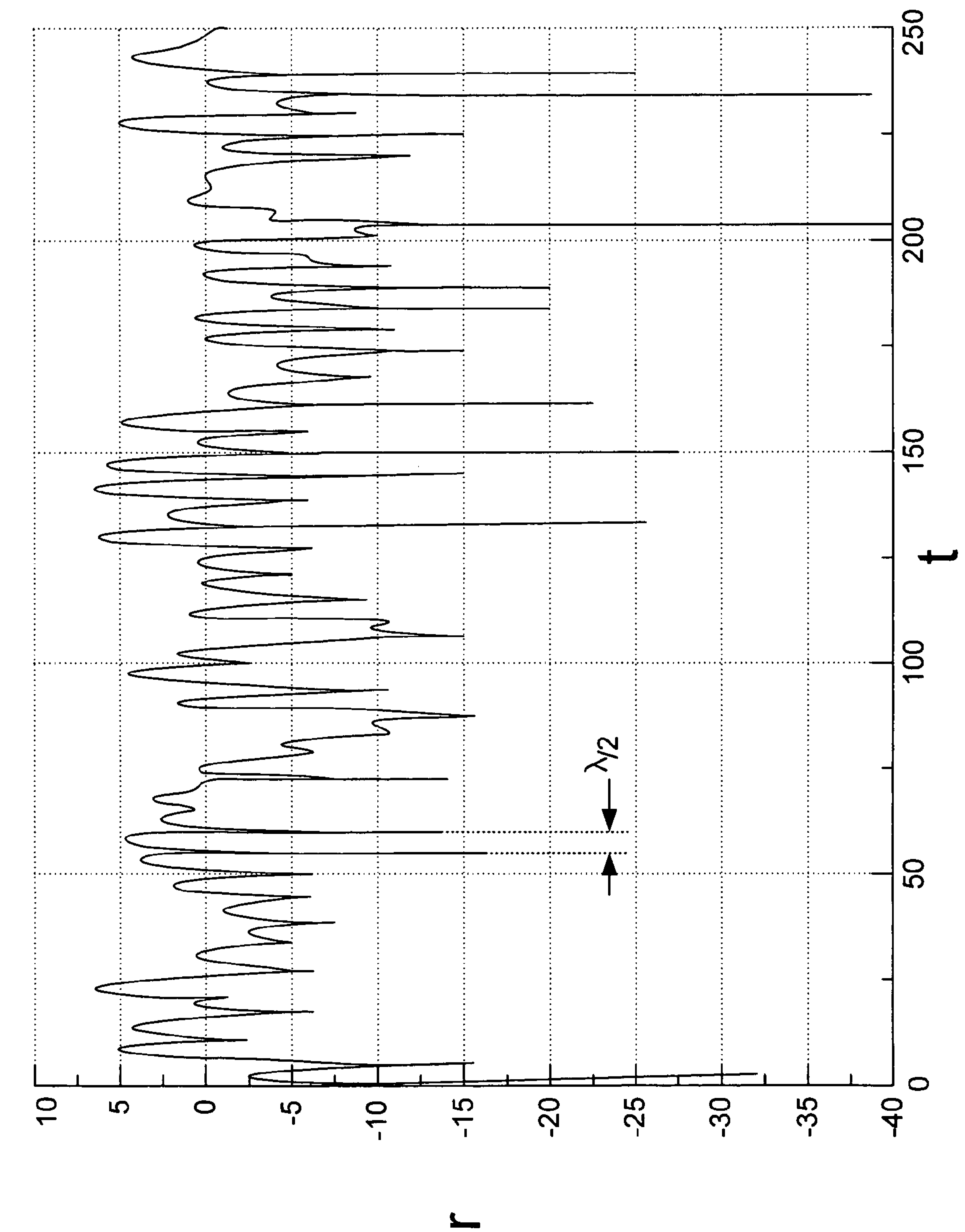


FIG. 2

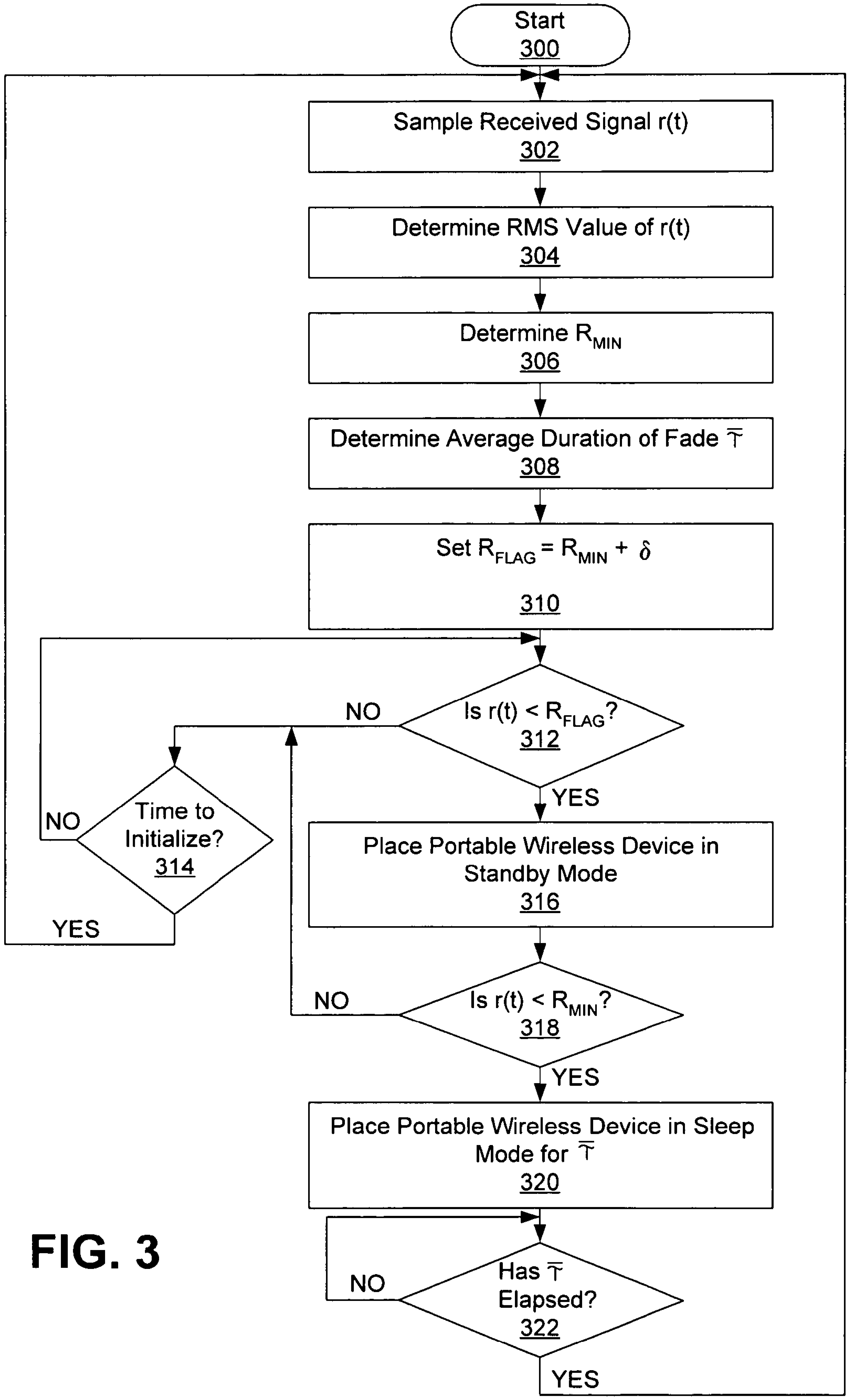

Start
300
Sample Received Signal r(t)
302
Determine RMS Value of r(t)
304
Determine R_{MIN}
306
Determine Average Duration of Fade $\bar{T}$
308
Set $R_{FLAG} = R_{MIN} + \delta$
310
Is $r(t) < R_{FLAG}$?
312
NO
YES
Time to Initialize?
314
NO
YES
Place Portable Wireless Device in Standby Mode
316
Is $r(t) < R_{MIN}$?
318
NO
YES
Place Portable Wireless Device in Sleep Mode for $\bar{T}$
320
Has $\bar{T}$ Elapsed?
322
NO
YES

FIG. 3

METHOD AND SYSTEM FOR POWER CONTROL IN WIRELESS PORTABLE DEVICES USING WIRELESS CHANNEL CHARACTERISTICS

TECHNICAL FIELD

The present invention relates generally to wireless systems, and more specifically to reducing the power consumed by portable devices in wireless systems.

BACKGROUND OF THE INVENTION

Wireless communications networks are commonplace today as a wide variety of appliances or portable wireless devices, such as audio and video media players and personal digital assistants, are being developed to provide users with content via wireless communications channels. A typical portable wireless device includes a processor for executing specific software and performing required tasks, memory for storing programs and data, a display for conveying information to a user, a keypad or other type of input device to allow a user to input data, and a wireless interface for communicating over a wireless communications channel to other devices in the network. Because a portable wireless device is typically battery powered, the power consumption of the components in the device is ideally minimized to extend the life of the batteries.

While all components in a portable wireless device consume power, the wireless interface is in many instances the component that consumes the largest portion of the overall power. As a result, lowering the power consumption of the wireless interface will significantly lower the overall power consumption of the portable wireless device. A variety of different approaches have been utilized to lower the power consumption of the wireless interface. These approaches generally involve turning off the wireless interface based upon the information being communicated over the wireless communications channel. For example, one approach is to temporarily turn off the operation of the interface whenever a receive buffer in the portable wireless device is full. The rationale of this approach is that since the portable device cannot receive and store any more incoming message packets being communicated over the wireless communications channel, the interface is temporarily placed in a sleep mode to conserve power until the device can once again receive and store more incoming packets. A performance penalty is experienced with this approach, however, due to the increased time required to communicate the required message packets to the device. This increased time is caused by the periods of time during which the interface is placed in the sleep mode and unable to receive and store any packets being communicated.

Another approach is to determine whether message packets to be communicated over the channel are directed to a particular portable device. When they are not, the wireless interface is placed in the sleep mode to save power. This approach may not, however, result in much power savings in networks where broadcast message packets are transmitted by a device in the network. A broadcast message is a message that is intended to be received and processed by all portable wireless devices proximate the transmitting device. Broadcast messages can significantly reduce the opportunities for a given portable wireless device to place its wireless interface into the sleep mode, reducing the power savings that may be realized using this approach.

There is a need for lowering the power consumption of portable wireless devices without adversely affecting the performance of the communications channel used to communicate with the device.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, a method controls the operation of devices which communicate over a wireless communications channel. The method includes determining a parameter of a received signal communicated over the wireless communications channel and determining a minimum threshold value of the received signal. An average duration of fade is determined using the parameter and the minimum threshold. The method detects whether the received signal is less than the minimum threshold value. At least one of the devices is placed in a sleep mode for approximately the average duration of fade in response to the received signal being detected as less than the minimum threshold value. The determined parameter of the received signal may be the root mean square value of the received signal.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a functional block diagram of a wireless network including a portable wireless device having reduced power consumption by disabling selected components as a function of the characteristics of a wireless communications channel according to one embodiment of the present invention.

FIG. **2** is a graph showing a sample Rayleigh fading envelope of a Rayleigh fading signal received by the portable wireless device of FIG. **1**.

FIG. **3** is a flow chart illustrating a power-reduction process executed by a power control component in the server system of FIG. **1** according to one embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

FIG. **1** is a functional block diagram of a wireless network **100** including a portable wireless device **102** having reduced power consumption due to the operation of a power control component **104** according to one embodiment of the present invention. In operation, the power control component **104** disables selected components in the portable wireless device **102** as a function of the characteristics of a received signal r(t) received on a wireless communications channel **106**, as will be explained in more detail below. In this way, the power control component **104** reduces the power consumption of the portable wireless device **102** by preventing the operation of certain components in the device during times when the quality of performance of the channel **106** is below an acceptable level.

In the following description, certain details are set forth in conjunction with the described embodiments of the present invention to provide a sufficient understanding of the invention. One skilled in the art will appreciate, however, that the invention may be practiced without these particular details. Furthermore, one skilled in the art will appreciate that the example embodiments described below do not limit the scope of the present invention, and will also understand that various modifications, equivalents, and combinations of the disclosed embodiments and components of such embodiments are within the scope of the present invention. Embodiments including fewer than all the components of any of the respective described embodiments may also be within the scope of the present invention although not expressly described in detail below. Finally, the operation of well known components and/or processes has not been shown or described in detail below to avoid unnecessarily obscuring the present invention.

The portable wireless device **102** includes a wireless interface **108** that communicates with a server system **110** over the wireless communications channel **106**. The power control component **104** is contained in the server system **110**, which typically corresponds to a stationary access point or other network device in the wireless network **100**. Although the wireless network **100** has a client-server architecture with the portable wireless device **102** corresponding to a client system, the wireless network may have different architectures in other embodiments of the present invention. The server system **110** provides the portable wireless device **102** access to a network **111** such as the Internet via the communications channel **106**.

The wireless interface **108** demodulates and decodes received signals from the server system **110** and provides corresponding data to a processor **112**, which executes software to process the data and to perform desired calculations or tasks. The wireless interface **108** also encodes and modulates data received from the processor **112**, and communicates the data over the wireless communications link **106** to the server system **110**. A memory **114** stores programs executed by the processor **112** and also stores associated data. A user input device **116**, such as a keypad, is coupled to the processor **112** and allows a user of the portable wireless device **102** to provide input to the device. A user output device **118**, which may be a visual display and/or a speaker, is coupled to the processor **112** and provides output to a user of the device **102**.

In operation, the power control component **104** monitors the received signal r(t) from the wireless interface **108** in the portable wireless device **102** and executes a power-reduction process to selectively activate and deactivate the wireless interface as a function of the received signal, thereby lowering the power consumption of the portable wireless device. More specifically, the power control component **104** monitors the received signal r(t) to detect "fading" of the received signal. The term fading refers to random fluctuations of the amplitude and phase of the received signal r(t) due to variations in the operational characteristics of the wireless communications channel **106**. These variations in operational characteristics are caused by signals propagating over the wireless communications channel **106** between the portable wireless device **102** and the server system **110** traveling over multiple reflective paths, which is a phenomenon referred to as multiple path propagation. Also note that fading of signals communicated over the channel **106** occurs for signals propagating in both directions, namely from device **102** to server system **110** and from server system to device. The terms fading, fade, and "fade condition" may be used interchangeably in the present description.

When the power control component **104** detects fading of the received signal r(t), the component communicates a power-down command to the wireless interface **108** via the channel **106**. In response to the power-down command, the wireless interface **108** is turned off or deactivated for an anticipated duration of the fading. This reduces the power consumption of the device **102** since the wireless interface **108** is not operating during fading while the quality of performance of the channel **106** is below an acceptable level. If the wireless interface **108** was attempting to communicate data via the wireless channel **106** during such a fade, this information may need to be communicated again because of the insufficient quality of performance of the channel. After the anticipated duration of the fade has lapsed, the power control component **104** communicates a power-up command via the channel **106** to the wireless interface **108**. In response to the power-up command, the wireless interface **108** is turned on or activated and resumes normal operation of communicating signals over the wireless channel **106**. In one embodiment, the anticipated duration of a fade is given by a statistically determined average duration of fade for the wireless channel **106**, as will be discussed in more detail below.

Before describing in more the detail the power-reduction process executed by the power control component **104**, the characteristics and model used for the wireless communications channel **106** will first be described. As will be understood by those skilled in the art, in the study of communications systems a communications channel is modeled or characterized to describe the properties of signals propagating over the channel, such as the attenuation of the power of a transmitted signal versus distance from an antenna generating that signal. For example, a communications channel may be modeled as an ideal free space channel where the region between a transmitting antenna and a receiving antenna is assumed to be free of any objects that might absorb or reflect electromagnetic signals propagating over the channel, including the atmosphere and the earth.

This assumption for an ideal free space channel is inadequate to accurately model most practical communications channels, like the wireless communications channel **106**. Instead, as previously mentioned, signals propagating over the wireless communications channel **106** can travel between the portable wireless device **102** and the server system **110** over multiple reflective paths, which results in fading of the received signal r(t). Fading may be characterized as being of different types, with each type being defined by the event causing the fading. One type of fading in the wireless communications channel **106** is caused by relatively small changes in the spatial separation between the portable wireless device **102** and the server system **110**, where these changes may be as small as one half the wavelength λ of the received signal. This type of fading is known as "small-scale" or "Rayleigh" fading because the amplitude envelope of the received signal is statistically described by a Rayleigh probability density function (pdf). A communication channel is characterized by Rayleigh fading if there are a large number of multiple reflective paths and there is no line-of-sight or direct propagation path between receiving and transmitting antennas. The wireless communications channel **106** is assumed to be characterized by Rayleigh fading in the present description. In addition to fading, relative motion between the portable wireless device **102** and server system **110** results in a Doppler frequency shift of signals communicated over the channel **106**, as will be understood by those skilled in the art.

FIG. **2** is a graph showing a sample Rayleigh fading envelope of the received signal r(t) received by the server system **110**. The graph shows the effects of Rayleigh fading on the amplitude of the received signal r(t) as a function of time. The amplitude of the signal r(t) is shown on the vertical axis as a decibel (dB) value about a root-mean-square (rms) value of the signal, and time is shown on the horizontal axis.

When the received signal r(t) is described as being below a specified value or threshold in the present description, this is referring to the amplitude of the received signal being below the specified value or threshold, as will be appreciated by those skilled in the art.

The power control component **104** utilizes a number of values in executing the previously mentioned power-reduction process, and formulas for these values will now be derived before describing the overall process in more detail. The received signal r(t) has an expected level crossing rate that is defined as the expected rate a which a Rayleigh fading envelope of the signal, normalized to a local root-mean-square (rms) level, crosses a specified level R in the positive going direction. The positive going direction of the received signal r(t) means the slope the time derivative $\dot{r}$ of the signal r is positive when the signal crosses the level R. If $\rho(R, \dot{r})$ is the joint density function of r and $\dot{r}$ evaluated at r=R, f_m is the maximum Doppler frequency of the signal r, and ρ is the normalized local rms amplitude RMS of the Rayleigh fading envelope of the received signal r(t), then the number of level crossings per second N_R is given by

$$N_R = \int_0^{\infty} \dot{r} p(R, \dot{r})\, d\dot{r} = \sqrt{2\pi}\, f_m \rho e^{-\rho 2}. \tag{1}$$

Now that the number of level crossing N_R has been determined, the average duration of a fade in the wireless communications channel **106** may be determined. The average duration of fade $\bar{\tau}$ is defined as the average time period for which the received signal r(t) is below the specified level R, which indicates how long a "bad fade" can be expected to last. A bad fade is thus a fade where the received signal r(t) is below the specified level R, and indicates a condition where the required quality of performance of the channel **106** cannot be ensured. The average duration of fade $\bar{\tau}$ is given by

$$\bar{\tau} = \frac{1}{N_R} Pr[r \le R], \tag{2}$$

where $Pr[r \leqq R]$ is the probability that the Rayleigh fading signal r(t) is below the specified level R. This probability is given by

$$Pr[r \le R] = \frac{1}{T} \sum_i \tau_i, \tag{3}$$

where τ_i is the duration of the fade and T is the observation interval of the fading signal r(t). Since the received signal r(t) satisfies a Rayleigh probability distribution $\rho(r)$ according to the assumed characteristics of the channel **106**, the probability that the Rayleigh fading signal is below the specified level R is given by

$$Pr[r \le R] = \int_0^R p(r)\, dr - 1 - \exp(-\rho^2). \tag{4}$$

From equations (1), (2), and (3), the average duration of fade $\bar{\tau}$ as a function ρ and f_m is given by

$$\bar{\tau} = \frac{\exp(\rho^2) - 1}{\rho f_m \sqrt{2\pi}}. \tag{5}$$

FIG. **3** is a flow chart illustrating in more detail the power-reduction process executed by the power control component **104** of FIG. **1** for detecting a fade condition in the wireless communications channel **106** and selectively activating and deactivating the wireless interface **108** for an expected duration of the fade condition according to one embodiment of the present invention. The process starts in step **300** and proceeds immediately to step **302** where the received signal r(t) is sampled at a sufficient rate, which is dependent on the frequency of the signal r(t). Using the samples of the signal r(t), the process goes to step **304** and initializes the power control component **104** (FIG. **1**) by determining an rms value of the signal r(t), which is designated RMS. The process is executed frequently enough to ensure that a new RMS value for the received signal r(t) is computed without the portable wireless device having moved too far from its location during the prior initialization. The frequency of the process must not be so high, however, that all samples of the received signal r(t) occur within a given fade, or else an accurate RMS value of the received signal will not be determined.

After the RMS value of the received signal r(t) has been determined in step **304**, the process goes to step **306** and determines a minimum threshold RMIN below which the received signal r(t) cannot drop to maintain a required quality of performance of the wireless communications channel **106**. As will be understood by those skilled in the art, the quality of performance of the communications channel **106** is characterized by a signal-to-noise ratio (SNR) and a corresponding bit error rate (BER), with the SNR being selected to achieve a desired BER of the channel. The desired BER determines the required SNR which, in turn, determines the value of RMIN. When the amplitude of the received signal r(t) drops below the threshold RMIN, the wireless interface **108** (FIG. **1**) should be deactivated since the SNR of the received signal is lower than required to maintain the specified BER.

Once the value of RMIN has been determined, the process goes to step **308** an uses equation (5) to calculate the average duration of fade $\bar{\tau}$. In equation (5), ρ is the normalized local rms amplitude RMS of the Rayleigh fading envelope of the received signal r(t) and is given by RMS/RMIN. From step **308** the process goes to step **310** and sets a flag R_{FLAG} to a value equal to the threshold RMIN plus a margin value δ. The margin value δ is simply a small value added to the threshold RMIN to indicate that the received signal r(t) is approaching the threshold.

After the value of the flag R_{FLAG} is set in step **310**, the process goes to step **312** and determines whether the received signal r(t) is less than the flag R_{FLAG}. When the determination is negative, the process goes to step **314** and determines if it is time to initialize the process once again. If this determination is positive, the process goes back to step **302** and the received signal r(t) is again sampled. If step **314** determines it is not time to initialize the process, the process goes back to step **312** and again determines whether the received signal r(t) is less than the flag R_{FLAG}.

When step **312** determines the received signal r(t) is less than the flag R_{FLAG}, the process goes to step **316** and the power control component **104** communicates a standby command over the channel **106** to place the portable wireless device **104** into a standby mode of operation. In the standby mode certain data is saved and other operations may be performed in anticipation of the portable wireless device **104** entering a sleep mode of operation. From step **316**, the process goes to step **318** and determines whether the received signal r(t) is less than the threshold RMIN. When this determination is positive, the process goes to step **320** and the power control component **104** communicates a sleep command over the channel **106** to the portable wireless device **102**. In response to the sleep command, the wireless interface **108** is deactivated to place the wireless device **102** into the sleep mode of operation. In the sleep mode, the wireless interface **108** does not communicate signals and has reduced power consumption. Other components in the portable wireless device **102** may also be deactivated responsive to the sleep command to further lower the power consumption of the device during the sleep mode. Note that in this embodiment of the power-reduction process, the standby and sleep commands collectively correspond to the power-down command described with reference to the wireless network **100** of FIG. **1**.

From step **320**, the process goes to step **322** and determines whether the average duration of fade $\bar{\tau}$ has elapsed. When this determination is positive, the power control component **104** communicates the power-up command over the channel **106** to the portable wireless device **102**. In response to the power-up command, the wireless interface **108** resumes communicating signals to the server system **110** over the channel **106**. Returning step **318**, if the received signal r(t) is not less than the threshold RMIN, the process goes back to step **314**.

The power-reduction process of FIG. **3** determines when the received signal r(t) is about experience a fade condition, meaning that the received signal will drop below the threshold RMIN. When a fade condition is detected, the wireless interface **108** and possibly other components in the portable wireless device **102** are deactivated to place the device into the sleep mode of operation and thereby lower the power consumption of the device. In this way, the portable wireless device **102** does not operate to communicate over the wireless communications channel **106** during periods when the quality of performance of the channel is below an acceptable level. This lowers the power consumption of the device **102** during this time and thus the overall power consumption of the device. The portable wireless device **102** operates in the sleep mode for the approximately the calculated average duration of fade $\bar{\tau}$, and once this time has lapsed the wireless interface **108** is activated and the device enters the normal operating mode and begins communicating over the wireless communications channel **106**. In this embodiment of the power-reduction process, the time to communicate the standby and sleep commands from the power control component **104** in the server system **110** is sufficiently less than the average duration of fade of the channel **106**.

The described embodiments of the power-reduction process and the portable wireless device **102** of FIG. **1** have the power control component **104** controlling only the wireless interface **108**. In other embodiments, the power control component **104** controls additional or different components in the portable wireless device **102** upon detecting a fade condition. One skilled in the art will appreciate that the power control component may be formed from suitable analog or digital circuitry, or both, and also could be formed from suitable software executing on the processor **112**. Similarly, the components **108** and **112**–**118** may be formed from suitable analog and/or digital circuitry, and, where appropriated, may be formed in software. The portable wireless device **102** may also include more, fewer, or different components depending on the designed functionality of the device. Moreover, the functions performed by each of the components **108**, and **112**–**118** in the portable wireless device **102** may be combined or divided differently among components contained in the device. For example, the wireless interface **108** can include circuitry to process the received standby, sleep, and power-up commands, or the processor **112** could execute software to process these commands. Similarly, the user input and output devices **116** and **118** could be combined into a single device such as a touch screen. One skilled in the art will understand suitable circuitry and/or software for forming the components **104**, **108**, and **112**–**118**. The wireless communications channel **106** may be any suitable type of wireless channel, such as a wireless local area network (WLAN) channel using suitable ones of the 802.11 family of Institute of Electrical and Electronics Engineers (IEEE) specifications.

In another embodiment of the wireless network **100** of FIG. **1**, the portable wireless device **102** also includes a power control component that operates in a manner analogous to the component **104** in the server system **110** to detect a fade condition and place the portable wireless device **102** into the sleep mode of operation. In further embodiment, the power control component **104** is contained in the portable wireless device **102** instead of the server system **110**, and operates in an analogous way to detect a fade condition and place the device **102** into the sleep mode. In still another embodiment, the power control component **104** could communicate a value for the average duration of fade to the portable wireless device **102** via the channel **106**. When a fade condition is detected, the wireless device **102** would enter the sleep mode responsive to the sleep command just as previously described, but would thereafter determine when the average duration of fade time had lapsed and enter the normal mode automatically after this time without the need for the power control component **104** in the server system **110** to transmit the power-up command.

One skilled in the art will understood that even though various embodiments and advantages of the present invention have been set forth in the foregoing description, the above disclosure is illustrative only, and changes may be made in detail, and yet remain within the broad principles of the invention. Therefore, the present invention is to be limited only by the appended claims.

What is claimed is:

1. A method of controlling the operation of devices which communicate over a wireless communications channel, the method comprising:

determining a parameter of a received signal communicated over the wireless communications channel;

determining a minimum threshold value of the received signal;

determining an average duration of fade using the parameter and the minimum threshold value;

detecting whether the received signal is less than the minimum threshold value;

placing at least one of the devices in a sleep mode for approximately the average duration of fade in response to the received signal being detected as less than the minimum threshold value;

setting a flag value that is equal to the minimum threshold value plus a margin value;

detecting whether the received signal is less than the flag value; and

placing at least one of the devices in a standby mode in response to the received signal being detected as less than the flap value.

2. The method of claim 1 wherein determining a parameter of a received signal comprises determining a root mean square value of the received signal.

3. The method of claim 2 wherein the average duration of fade is given by the following formula:

$$\bar{\tau} = \frac{\exp(\rho^2) - 1}{\rho f_m \sqrt{2\pi}}$$

where f_m is the maximum Doppler frequency of the received signal, and ρ is the normalized local rms amplitude of a Rayleigh fading envelope of the received signal.

4. The method of claim 1 further comprising placing the at least one device in a normal mode of operation approximately the average duration of fade after the portable wireless device is paced in the sleep mode.

5. The method of claim 1 wherein the devices that communicate over the wireless communications channel comprise a portable wireless device and a server system, and wherein the received signal comprises a signal transmitted by the portable wireless device and received byte server system.

6. The method of claim 5 wherein placing at least one of the devices in a sleep mode for the average duration of fade comprises:

communicating a sleep mode command from the sewer system to the portable wireless device in response to the received signal being detected as less than the minimum threshold value;

placing the portable wireless device in the sleep mode for approximately the average duration of fade responsive to the sleep mode command; and

placing the server system in the sleep mode for approximately the average duration of fade in response to the received signal being detected as less than the minimum threshold value.

7. The method of claim 6 further comprising communicating a wake-up command from the sewer system to the portable wireless device approximately after the average duration of fade.

8. The method of claim 1 wherein the devices that communicate over the wireless communications channel comprise a portable wireless device and a server system, and wherein the received signal comprises a signal transmitted by the server system and received by the portable wireless device.

9. A method of controlling operation of portable wireless device that communicates over a wireless communications channel:

sampling a received signal communicated over the wireless communications channel;

determining a root-mean-square value of the received signal from the samples;

determining a minimum threshold of the received signal;

determining an average duration of fade using the rms value and the minimum threshold;

setting a flag value equal to the minimum threshold plus a margin value;

detecting whether the received signal is less than the flag value;

communicating a standby command over the wireless communications channel;

placing the portable wireless device in a standby mode responsive to the standby command;

detecting whether the received signal is less than the minimum threshold;

communicating a sleep command over the wireless communications channel;

placing the portable wireless device in a sleep mode responsive to the sleep command; and

after approximately the average duration of fade, placing the portable wireless device in a normal made of operation.

10. The method of claim 9 wherein the average duration of fade is given by the following formula:

$$\bar{\tau} = \frac{\exp(\rho^2) - 1}{\rho f_m \sqrt{2\pi}}$$

where f_m is the maximum Doppler frequency of the received signal, and ρ is the normalized local rms amplitude of a Rayleigh fading envelope of the received signal.

11. The method of claim 9 wherein the portable wireless device communicates over a wireless communications channel to a second wireless device, and wherein sampling a received signal comprises sampling a signal transmitted over the wireless communications channel and received by the second wireless device.

12. A system for controlling operation of a portable wireless device that communicates over a wireless communications channel comprising:

a power control component adapted to receive a signal communicated over a wireless communications channel, the power control component operable

to set a flag value that is equal to a minimum threshold value for a received signal plus a margin value,

to detect a fade condition of the received signal by detecting whether the received signal is less than the flag value,

and from this detected fade condition to generate an avenge duration of fade value, and the component further operable responsive to detecting the fade condition to transmit a sleep mode command over the wireless communications channel; and

a portable wireless device, including a processor, and a wireless interface coupled to the processor and operable in a normal mode to communicate signals over a wireless communications channel, and the wireless interface being adapted to receive the sleep command communicated over the wireless communications channel and operable in a sleep mode for approximately an average duration of a fade condition in response to the sleep command.

13. The portable wireless device of claim 12 wherein the wireless interface is adapted to receive a power-up command communicated over the wireless communication channel and is operable responsive to the power-up command to terminate operation in the sleep mode and commence operation in the normal mode.

14. The portable wireless device of claim 12 further comprising:

an input device coupled to the processor;

an output device coupled to the processor; and

a memory coupled to the processor.

15. A power control component adapted to receive a signal communicated over a wireless communications channel,

the power control component operable

to set a flat value that is equal to a minimum threshold value for a received signal plus a margin value,

to detect a fade condition of the received signal by detecting whether the received signal is less than the flag value,

and from this detected fade condition to generate an average duration of fade value, and the component further operable responsive to detecting the fade condition to transmit a sleep mode command over the wireless communications channel, the sleep command containing information to cause a device receiving the command to enter a sleep mode of operation for approximately the average duration of fade.

16. The power control component of claim 15 wherein the power control component detects a fade condition of the received signal by determining an rms value and a minimum threshold value of the received signal, and determining an average duration of fade using the rms and minimum threshold values.

17. The power control component of claim 16 wherein the power control component is further operable to transmit a power-up command over the wireless communications channel approximately the duration of fade after transmitting the sleep mode command.

18. A wireless network device adapted to receive a signal over a wireless communications channel, the wireless network device including

a power control component operable

to set a flag value that is equal to a minimum threshold value for a received signal plus a margin value,

to detect a fade condition of the received signal by detecting whether the received signal is less than the flat value, and

to calculate an average duration of the detected fade condition,

the wireless network device being further operable responsive to the power control component detecting a fade condition of the received signal by detecting that the received signal is less than the flag value, to transmit a sleep mode command over the wireless communications channel, the sleep mode command including information indicating the average duration of fade such that signals will not be communicated to the device over the communications channel for approximately the average duration of fade.

19. The wireless network device of claim 18 wherein the wireless network device is part of a wireless network having a client-server architecture, and wherein the wireless network device corresponds to a server system in the network architecture.

20. The wireless network device of claim 18 wherein the power control component detects a fade condition of the received signal by determining an rms value and the minimum threshold value of the received signal, and determining an average duration of fade using the rms and minimum threshold values.

21. The wireless network device of claim 20 wherein the power control component transmits the average duration of fade along with the sleep mode command.

22. The wireless network device of claim 18 wherein the wireless network device is further operable to transmit a power-up command over the wireless communications channel approximately the duration of fade alter transmitting the sleep mode command.

23. A computer-readable medium containing instructions for controlling a computer system to control the operation of a device which communicates over a wireless communications channel by performing the operations of:

determining a parameter of a received signal communicated over the wireless communications channel;

determining a minimum threshold value of the received signal;

determining an average duration of fade using the parameter and the minimum threshold value;

detecting whether the received signal is less than the minimum threshold value;

placing the device in a sleep mode for approximately the average duration of fade in response to the received signal being detected as less than the minimum threshold value;

setting a flag value that is equal to the minimum threshold value plus a margin value;

detecting whether the received signal is less than the flag value; and

placing at least one of the devices in a standby mode in response to the received signal being detected as less than the flat value.

24. The computer-readable medium of claim 23 wherein determining a parameter of a received signal comprises determining a root mean square value of the received signal.

25. The computer-readable medium of claim 24 wherein the average duration of fade is given by the following formula:

$$\overline{\tau} = \frac{\exp(\rho^2) - 1}{\rho f_m \sqrt{2\pi}}$$

Where f_m is the maximum Doppler frequency of the received signal, and ρ is the normalized local rms amplitude of a Rayleigh fading envelope of the received signal.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 7,190,980 B2
APPLICATION NO. : 10/769044
DATED : March 13, 2007
INVENTOR(S) : Vinay Kumar Deolalikar et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In column 9, line 5, in Claim 1, delete “flap” and insert -- flag --, therefor.

In column 9, line 24, in Claim 4, delete “paced” and insert -- placed --, therefor.

In column 9, line 29, in Claim 5, delete “byte” and insert -- by the --, therefor.

In column 9, line 34, in Claim 6, delete “sewer” and insert -- server --, therefor.

In column 9, line 46, in Claim 7, delete “sewer” and insert -- server --, therefor.

In column 10, line 15, in Claim 9, delete “made” and insert -- mode --, therefor.

In column 10, line 48, in Claim 12, delete “avenge” and insert -- average --, therefor.

In column 11, line 10, in Claim 15, delete “flat” and insert -- flag --, therefor.

In column 11, line 43, in Claim 18, delete “flat” and insert -- flag --, therefor.

In column 12, line 14, in Claim 22, delete “alter” and insert -- after --, therefor.

In column 12, line 41, in Claim 23, delete “flat” and insert -- flag --, therefor.

Signed and Sealed this

Twenty-fourth Day of November, 2009

David J. Kappos

David J. Kappos
Director of the United States Patent and Trademark Office